NAVAL POSTGRADUATE SCHOOL
Monterey, California

EC 3210 FINAL EXAM 12/89Po

- This exam is open book and notes.
- There are five problems; each is equally weighted.
- Partial credit will be given; be sure to do some work on each problem.
- Be sure to include units in your answers.
- Please circle or underline your answers.
- Show *ALL* work.
- Write only your name on this sheet.
- Exams and course grades will be available in the ECE Office in Sp 437 on Tuesday, 26 December.

Course grade: _____

| | | | |
|---|---|---|---|
| 1 | | 4 | |
| 2 | | 5 | |
| 3 | | | |
| Total | | | |

Name: _____

1. The carbon–monoxide (CO) laser is a four–level laser whose energy levels have the properties listed below. The laser operates at a cryogenic temperature of 77K at a pressure of 10 Torr. Write an expression for the linewidth function $g(\nu)$ if the laser is lifetime and collision broadened. (The collision cross–section for a CO–CO collision is $7.03\times10^{-21}$ m$^{-2}$.)

| Energy level | Energy (eV) | Lifetime ($\mu$s) |
|---|---|---|
| 3 | 3.10 | $1.0\times10^{-3}$ |
| 2 | 1.91 | 2.0 |
| 1 | 1.5 | 0.10 |
| Ground | 0 | $\infty$ |

(*Note: This data is fictitious and does not represent the properties of an actual CO laser.*)

2. A Gaussian laser beam ($\lambda = 800$ nm) propagates from left to right. The beam has a spot size of 8 mm and a radius of curvature of phase of +15 m at a location that is 25 m from the origin (of the $x - y - z$ coordinate system). Find the beam spot size *and* radius of curvature of the phase at a location that is 9.5 m from the origin.

3. A greybody emitter has an emissivity of 0.8 and a temperature of 500K.

   (a) Calculate the wavelength of peak spectral photon emittance. (*5 points*)

   (b) Suppose that the emissivity is reduced to a value that is 50% of its original value and that the temperature is raised to a valued that is 110% of its initial value. Calculate the factor by which the spectral photon emittance will change at the wavelength calculated in Part a. (*15 points*)

4. A mode–locked laser produces a train of pulses having a peak power of 10 watts, an average power of 50 mW, and a period of 60 ps. Calculate the longitudinal coherence length of this laser.

5. Calculate the required unsaturated population inversion *density* (in units of atoms·m$^{-3}$) to achieve an unsaturated gain coefficient of 0.5 m$^{-1}$ in $CO_2$. The transition wavelength is 10.6 $\mu$m and the Einstein absorption coefficient is $A_{21} = 200$ s$^{-1}$. The transition is Doppler–broadened with a temperature of 400K. You may assume that $n = 1$.